



A multi-actor, participatory approach to identify policy and technical barriers to better farming practices that protect our drinking water sources

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HIGHLIGHTS

- Protection of drinking water from nutrients and pesticides requires a good uptake of BMPs.
- The uptake of BMPs was assessed by a participatory approach across Europe.
- Barriers preventing the uptake of obligatory and voluntary BMPs were identified.
- Barriers were related to policy tools at the national and European scale.
- Social acceptance among all actors and communication was required right from the start.

GRAPHICAL ABSTRACT



Abbreviations: SUD, Sustainable Use of Pesticides Directive; WFD, Water Framework Directive; BMPs, Best Management Practices; MMs, mitigation measure; PPPs, plant protection products; RBMPs, River Basin Management Plans; CAP, Common Agricultural Policy; PoMs, Programme of Measures.

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ABSTRACT

Despite an improvement of water quality across Europe there are many pollution hotspots for both nitrates and PPPs, mainly due to agricultural activities. The BMPs and MMs to reduce pollution from agriculture are well known, and there are policy instruments in place to ensure drinking water standards, but the current approach has not been efficient enough. Within the H2020 Water Protect project the premise was that there is a need for a multi-actor, participatory approach to tackle the issue from a new angle, and to assess why the uptake of known BMPs and MMs was not better among farmers. Seven “Action Labs” were selected that represent major physical, socio-economical, cultural and farming settings across Europe. A methodology of multi-actor engagement was chosen but with different approaches due to the local context. Initially the level of farmers’ awareness about water quality issues was matched to the observed uptake rates of BMPs and MMs. In a second survey barriers hindering the uptake of measures were identified. The first survey revealed a low general awareness on the potential pollution to drinking water sources. Despite this, between 24% to 88% of the surveyed farmers per Action Lab were already voluntarily adopting one quarter of the selected BMPs and MMs. The second survey demonstrated the need to address organisational, legislative, sociological and technical barriers. The lack of coordination between different institutional bodies promoting measures and the financial incentives needed to invest and operate these often-costly measures need to be considered. The multi-actor, participatory approach with its improved awareness and collaboration made it possible to identify the crucial factors for improvement - to build a social acceptance among all actors and communicate the issues and solutions from the start.

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1. Introduction

High-quality, safe, and sufficient drinking water is essential for life: we use it for drinking, food preparation and cleaning. However, more than half of the river and lake water bodies in Europe are reported to be in less than good ecological status. The main environmental pressures are point (38%) and diffuse source pollution (18%) and about 25% of groundwater across Europe is in poor chemical status (EEA, 2018). The wider research community recognises that management of water in a sustainable way “is the key for the future of food and agriculture” (OECD, 2020a). The 2030 Agenda for Sustainable Development acknowledges the importance of water quality and includes a specific water quality objective in Sustainable Development Goal (SDGS, 2020). Farming accounts for between 30% and 60% of local water used across Europe and contributes to water pollution sourced from nutrient, pesticide and other pollutant discharges (e.g. tractor oils) (OECD, 2020b). Through pollution from nitrates and Plant Protection Products (PPPs), agriculture is the main source of environmental pressures causing failure to achieve good chemical status in groundwater (EEA, 2018). Improvement of water resource use efficiency and reduction of water pollution from agricultural systems is seen as one of the main policy challenges. Several approaches and tools, such as monitoring and models applied at different scales, and innovations for increasing the efficiency of agricultural production are used in the field of water quality to support planners and policy-makers in designing cost-effective measures for addressing water pollution in agriculture (Mateo-Sagasta et al., 2017).

Water quality in surface and ground waters has generally improved across Europe thanks to the adherence to waste water treatment standards for point emissions and the uptake of BMPs and MMs by the farming sector for diffuse emissions. However, there are still a number of pollution hotspots across Europe for both nitrates and PPPs, largely due to agricultural activities. The BMPs and the MMs to reduce pollution from nitrates and PPPs are well known, there are also policy instruments in place to ensure that drinking water standards are met, but drinking water companies are still being required to invest and operate drinking water treatment facilities to deliver drinking water that meet the required standards – so in essence the current approach is not working and more should be done to reduce costly end of pipe drinking water treatment solutions. Therefore, the H2020 Water Protect project started with the premise that a different multi-actor, participatory approach was needed to tackle the issue from a new angle and to get to the bottom of why farmers are not sufficiently taking up known BMPs and MMs to protect drinking water sources. We selected seven Action

Labs across Europe that represent some of the major differences in physical, socio-economical, cultural and farming systems across Europe.

Best Management Practices (BMPs) and Mitigation Measures (MMs) are key elements to limit or prevent water and environmental pollution from agricultural activities. The analysis of their efficacy has thus raised several scientific projects and multiple exchanges between regulatory authorities. A number of initiatives have been undertaken across Member States to stimulate their uptake (TOPPS <http://www.topps-life.org>, MAGPIE <https://www.setac.org/magpie>, COMPASS <https://balticcompass.org/>). This has resulted in the genesis of a wide variety of approaches, implemented at national levels such as good agricultural practices or legislative measures. The increased uptake of measures to reduce nitrogen pollution from agriculture and improvements in urban waste water treatment have led to a steady reduction in average nitrogen concentrations in rivers from 2.7 to 2.1 mg NO₃/l (1992 to 2012) and average concentrations in groundwater are well below the Groundwater Quality Standard of 50 mg NO₃/l (European Commission, 2012). However, there remains persistent hot spot areas across Europe at the regional level with nitrate levels well above these averages, so the need to increase the uptake of measures in these areas is paramount to the continued sustainability of drinking water extraction (European Environment Agency, 2012).

Several countries in Europe report aquifers having concentrations of PPPs that exceed the Environmental Quality Standard (EQS). The reduction of the pollution of drinking water sources by PPPs and fertilisers used by the agricultural sector remains the biggest challenge. Despite the increased integration of policies to deliver clean and safe drinking water over the last 30 years there is clearly a need to increase the engagement between interdependent actors and stakeholders (European Environment Agency, 2012). Efficiency and innovation do not seem to be the only parameters that can solve the challenge of sustainable and low-impact agriculture, which instead requires a much more complex analysis with an integrated approach. An integrated approach involves an understanding of technological problems, social behaviour of rural communities, economic constraints, the legal and institutional framework and contextual agricultural practices (Chartzoulakis and Bertaki, 2015). Belmans (2018) suggests that a move towards a more “horizontal” and “participatory” water governance between the various actors and stakeholders would be more productive: water companies, farmers, nature conservation NGOs, plant protection product producers, fertilizer producers, food and retail businesses, consumer organisations, environment agencies and ministries. There are other approaches, such as stewardship programmes, financed by food and drink companies to

protect the quality of local water supplies (Newborne and Dalton, 2019). In a similar vein certification schemes such as the European Water Stewardship (EWS) Certification Scheme (<https://ews.info/>) have the same goal to organize companies to improve the environmental footprint of their value chain and protect water resources (Jones et al., 2014).

In this framework, the H2020 funded project WaterProtect was established with the aims to: (1) analyse whether the solutions offered by the existing governance systems can adequately cover the impact by the agriculture; (2) demonstrate how selected mitigation measures have an impact on improving water quality; and (3) contribute to the effective uptake and realisation of Best Management Practices to deliver good water quality.

A pan-European, multi-actor approach was adapted in the context of seven rural or mixed rural/urban Action Labs (also known as Living Labs) to determine barriers and factors that hinder the uptake of BMPs and MMs to protect drinking water sources from nitrates and PPPs and that have an impact on farmers' decision making and strategies. The hypothesis is that water and agriculture policy reforms to support farmers and policy makers in their decision-making requires an in-depth understanding of the local context and of the policy-related driving factors that impact on water quality. On the basis of this understanding, recommendations were provided to improve awareness, collaboration and in some case the uptake of BMPs and MMs in the Action Labs.

2. Materials and methods

2.1. Area of study: Seven Action Labs across Europe

The seven Action Labs are located in six different environmental zones (WUR, 2011) which cover 75% of the area relevant for agriculture (Fig. 1, Table 1). The main farming systems in the EU are considered:

mixed farming (two Action Labs), field crops (three Action Labs), and permanent crops (two Action Labs). Among the seven Action Labs, there are three rural land uses (Romania, Ireland, Denmark) and one mixed urban and rural land uses (Belgium) with small water supplies. Larger Action Labs, including two mixed urban and rural land uses (Italy, Spain) and one rural land use (Poland), are delivering drinking water to hundreds of thousands of inhabitants. In five of the Action Labs the focus is on groundwater that is used either in public supply (Denmark), or both public and private supply (Ireland) or used locally from private wells as drinking water or for agricultural use (Spain, Italy, Romania). In the Action Labs, the water quality of water resources is under pressure from manuring and agro-chemicals, but different Action Labs chose specific targeted pollutants: four Action Labs focussed mainly on PPPs (Belgium, Italy, Ireland, Spain), whereas three worked mainly on nitrates (Denmark, Poland, Romania).

2.2. Multi-actor engagement

Sustainable agriculture is the result of complex “systemic interactions” between different actors involved in various ways, such as researchers, farmers, entrepreneurs, regional and national organisations, etc. Indeed, a complex socio-ecological issue such as water quality related to agriculture cannot be solved by just one actor but rather from a multi-actor approach perspective (Belmans, 2018). All of them have different forms of knowledge (practical, scientific, policy based, etc.) and there is the need to create conditions for interaction between them and combine their knowledge, perspectives, resources, and experiences, to identify and discuss solutions and new ideas. Therefore, all the actors identified in the seven Action Labs that were considered to have an influence on or to be influenced by the environment and the farming systems, were invited to engage in the study development and activities. Since it is recognized that at the context level there is not a “one fits all approach”, in each Action Lab the stakeholder



Fig. 1. Location of the seven Action Labs across Europe.

Table 1

Overview of the environmental and farming system characteristics of the seven Action Labs, including the pollutant focus (in bold).

Country ^a	BE	IE	PL	DK	IT	ES	RO
Action Lab	Bollaertbeek	Wexford	Gowienica	Vester Hjerik	Val Tidone	Lower Llobregat	Mara
Environ-mental zone ^b	ATC	ATC	CON	ATN	MDN	MDS	ALS
Land use	Mixed urb/rur	Rural	Rural	Rural	Mixed urb/rur	Mixed urb/rur	Rural
Farming system	Field crops	Grass & field crops	Field crops	Field crops	Vineyards	Minor fruit & veg	Extensive grassland/subsistence
Size	Small	Small	Interm	Interm	Small to large	Interm	Small
	~23 km ²	~10 km ²	~60 km ²	~27 km ²	~206 km ²	~120 km ²	~20 km ²
Drinking water ^c	SW	GW private & public	SW	GW public	GW private	SW & GW private	GW private
Pollutant(s) surveyed	PPPs	Nitrates & PPPs	Nitrates & PPPs	Nitrates	Nitrates & PPPs	Nitrates & PPPs	Nitrates
Irrigation	No	No	Yes	No	Yes	Yes	Yes

^a Country: BE Belgium; IE Ireland; PL Poland; DK Denmark; IT Italy; ES Spain; RO Romania.^b Environmental Zone: ATC Atlantic Central; CON Continental; ATN Atlantic North; MDN Mediterranean North; MDS Mediterranean South; ALS Alpine South.^c SW surface water, GW groundwater.

involvement was conceptualised as an “active engagement” that followed a stepwise approach. The approach included both water quality analysis (e.g. participatory monitoring) and stakeholders' analysis, with different levels of participation based on actors' roles that ranged from specific consultations to active involvement in the project (e.g. hosting demonstrations, facilitating meetings, field visits etc....).

Based on the initial knowledge status of each Action Lab, the level of collaboration and the specific local objectives, the approach led to a range of different strategies throughout the overall process. A detailed description of each strategy adopted is provided by Calliera et al. (2020, submitted to this VSI). In summary, the strategies included: (i) *face-to-face meetings* (such as seminars, workshops, community events, or site tours), an exchange/informing qualitative “dialogue-based method” that allows greater spontaneity and interaction between the researchers and participants; (ii) *surveys*, exchange questionnaire-based quantitative tools, where stakeholders are requested to individually answer questions by choosing from a limited number of provided answers; (iii) *participatory monitoring*, the engagement of farmers, farmers associations and farmer's consultant organisation in the design and the setup of water monitoring for the catchment; (iv) *participatory training approach and demonstration farm*, exchange/informing activities able to identify and bridge “the gap between what is and what should be in terms of incumbents' knowledge, skills, attitudes, and behaviour for a particular situation at one point in time” (Farm Path Project, 2014). The collation of information underpinning the multi-actor engagements allows us to summarise the level of stakeholder awareness at the beginning of the project in each Action Lab, list the stakeholders involved and define the strategies for engagement (Table 2).

2.3. Coherence of agricultural and environmental policies to protect drinking water sources

2.3.1. Background and identification of the relevant policy architecture

To better define the context of the study, it was necessary to carry out an analysis of the water and agriculture related policies, so as to identify the policy-related driving factors that impact on water quality in the Action Labs. The analysis considers the critical success factors that enhance the effective integration of environmental water concerns into agricultural practices, including the contribution of agricultural and environmental policies and regulatory frameworks.

Agriculture and water management go hand in hand, and within the EU policies related to these two sectors there are many opportunities for synergies and reinforcements (European Commission, 2017). However, the EU water and agriculture policies also have individual objectives and different implementation mechanisms, which creates differences in the depth and coherence of their coordination.

The first element worth noting is that the Common Agricultural Policy (CAP) for the period 2013–2020 is a fully integrated policy, meaning that standards are set at EU level with Member States having little room

for flexibility in the implementation, except for the Rural Development Pillar measures. Consequently, the EU legal framework is built on directly applicable Regulations, so there is no requirement for transpositions.

On the other hand, environmental policy, including water policy, has been founded completely on the subsidiarity principle. This means that major policy goals are agreed at the EU level, while Member States are given the powers to implement and enforce by transposing the Directives into national legislation.

The main environmental policy instruments related to water that are to be considered here are:

- EU Water Framework Directive 2000/60/EC (WFD), adopted by the European Parliament and Member States in 2000, an integrated, river basin management approach to clean and keep clean all European waters (European Parliament and Council, 2000);
- EU Floods Directive 2007/60/EC (FD), that requires the assessment and management of flood risks by Member States, to assess if all water courses and coast lines are at risk from flooding and to take adequate and coordinated measures to reduce flood risk (European Parliament and Council, 2007);
- EU Drinking Water Directive 98/83/EC (DWD), which mandates minimum health standards in water intended for human consumption, making linkages with other water-related policies (European Commission, 1998);
- EU Groundwater Directive 2006/118/EC (GWD), which complements the Water Framework Directive (WFD) and sets groundwater quality standards, introducing measures to prevent or limit inputs of pollutants into groundwater (European Parliament and Council, 2006); and,
- EU Directive 2013/39/EU, which establishes environmental quality standards for priority substances in surface waters (e.g. identification of new harmful substances, updating of environmental quality standards, introduction of a new “watch list” mechanism) (European Parliament and Council, 2013).

For EU agriculture policies, the cross-compliance requirements (set of minimum agricultural production standards) and the measures included in the Rural Development Plans are those that define the framework for the farmers, in order to benefit from EU subsidies. Being part of cross-compliance, Directive 128/2009 for the Sustainable Use of Pesticides (SUD) (European Parliament and Council, 2009) is an important instrument to help achieve good water status, although broader in scope, it includes relevant measures aimed at protecting the water resources by restricting the use in certain areas and by implementing buffer zones and other measures to reduce run-off and leaching.

Also included in cross-compliance is the Nitrates Directive (Council of the European Union, 1991) that aims at the reduction of pollution from agricultural nitrogen. Several other EU policies have a rather indirect impact on water and will not be considered in this analysis. For example, the recent EU circular economy package includes provisions like the rules for water reuse or the new rules on fertilisers that open the

Table 2

Summary across the seven Action Labs of the initial levels of stakeholder awareness, the stakeholders involved and the strategies for engagement.

Action Lab	Initial level of awareness	Actors involved	Strategies for engagement
Bollaertbeek	<ul style="list-style-type: none"> Farmers are little aware of the problem in their area. They know water quality is important, but they think local water quality is sufficient and they do not think that their agricultural activities have a negative influence on water quality. Some contract sprayers do know the situation is bad, others didn't acknowledge the situation at all. The other actors (interviewed at the start of the project) know the quality of the water is bad. 	Action lab leader(s) INAGRO (farmer advisory and research) ILVO (research) VITO (research) Bayer Chemical producers Distributors of plant protection products Representatives of chemical producers Spraying machine dealers Farmers Contract sprayer Farmer advisory and unions Water producers and suppliers of drinking water Regional/national government Local government	Informing – newsletter Informing – presentation Exchange – bilateral conversation Exchange – multi-actor conversation Exchange – questionnaire/survey Exchange – implementation training Exchange – field visit Exchange – interactive workshop
Vester Hjerik	<ul style="list-style-type: none"> No big awareness about the drinking water situation among the public. People are relying on the authorities and waterworks to take action if there is a problem. 	Action lab leader(s) UCPH (research) GEUS (research) SEGES Research Farmers (consumers) Farmer advisory and unions Water producers and suppliers of drinking water Regional/national government Local government Inhabitants – consumers	Informing – newsletter Exchange – bilateral conversation Exchange – multi-actor conversation Exchange – questionnaire/survey Exchange – interactive workshop
Wexford	<ul style="list-style-type: none"> There is a good awareness of PPPs, such as MCPA, potentially causing a problem for Irish drinking water. The number of PPP failures has increased in recent years. Seven suppliers, serving; 60,500 people have been reported to have a problem with MCPA in Ireland. There is a poor knowledge on the underlying processes of MCPA reaching water. It was recognized that we need more knowledge on the transfer pathways and the residence time/breakdown. There was a perception that MCPA is only incidentally lost to water via surface pathways. Due to the heterogeneity of the landscape a targeted approach supported by science is needed to mitigate MCPA loss to water 	Action lab leader(s) Teagasc Chemical producers Animal and Plant Health Association (APHA) Hygeia Chemicals Ltd. Research NUFARM Ulster University Teagasc Students Farmers Agricultural Catchments Programme Farmer unions and advisories Famers of the catchments Water producers and suppliers of drinking water Teagasc advisors Regional/national government Agricultural Sustainability Support Advisors (ASSA) Irish Water National Federation of Group Water Scheme (NFGWS) Department of Agriculture Food and the Marine Local Authority Waters Programme (LAWPRO) Environmental Protection Agency (EPA) Pesticide Control Division of the Department of Agriculture Food and the Marine Local government Wexford County Council Food processors and distributors Glanbia Inhabitants – consumers Citizens – rural dwellers	Exchange – bilateral conversation Exchange – multi-actor conversation Exchange – questionnaire/survey Exchange – field visit Exchange – interactive workshop
Val Tidone	<ul style="list-style-type: none"> No data about the impact of viticulture on ground-water quality of Tidone Valley was available at the beginning of the project. Institutional data is poor for this area, but data on groundwater quality of Piacenza province is available in ARPAE's websites. Most of the farmers are not aware of the problem. There is no direct link between the monitoring results and the communication to them. One cooperative and one farm have set-up their 	Action lab leader(s) UCSC (University) ARPAE-ER (Environmental Agency) APCS (consumer organisation) Research Università Cattolica del Sacro Cuore Farmers Farmers of the Val Tidone catchment Farmer advisory and unions Confagricoltura (farmer representative) Coldiretti CIA (farmer representative) Consorzio Fitosanitario (farmers advisory)	Informing – newsletter Informing – presentation Informing – leaflet Exchange – bilateral conversation Exchange – multi-actor conversation Exchange – questionnaire/survey

(continued on next page)

Table 2 (continued)

Action Lab	Initial level of awareness	Actors involved		Strategies for engagement	
Gowienica	<p>organisation and production in compliance with the Italian standard VIVA using indicators for the improvement of their social, environmental and economic performance.</p> <ul style="list-style-type: none">• The Gowienica Miedwainńska River Basin has been operating as a nitrate vulnerable zone for 12 years until now and still some farmers have very little knowledge on this subject.• Lack of interest (or little interest) of inhabitants in the water quality state in the catchment.• Some farmers did not know that the Gowienica Miedwianska is a river.• The problem of water quality is known by farmers and by institutions related to water management and agriculture (NVZ area).• Non-agricultural and non-water management companies and inhabitants are not aware of the existing problem.• Non-agricultural local companies are not aware of the problem of water quality in the Gowienica river catchment. They assess surface and ground-water as of good quality. The tap water supplied to the recipients mentioned above is also assessed by them as of good quality.	Water producers and suppliers of drinking water	Axe Environment (farmers advisory) IRETI (drinking water production, supply and treatment) Po River Hydrographic District Basin Authority (river basin agency) ARPAE (Environmental protection agency) Piacenza (government provincial level) Regione Emilia Romagna (government regional level)	Exchange – implementation Exchange - field visit Exchange – interactive workshop	
		River basin/ environmental protection agency			
		Regional/national government			
		Local government	Borgonovo (municipality) Ziano (municipality) Castel San Giovanni (municipality) Pianello (municipality) Alta Val Tidone (municipality) Local health agency AUSL Provincial reclamation authority, Consorzio di Bonifica Piacenza		
		Food trader – Industry winery	Vicobarone winery - cellar (Cantina Vicobarone) (food processor and trader) Val Tidone winery - cellar (Cantina Val Tidone) (food processor and trader) Consorzio vini DOC Colli Piacentini (local business) Consumer associations		
		Inhabitants - consumers			
		Action lab leader(s)	Polish Geological Institute - National Research Institute (PGI-NRI) Institute of Technology and Life Sciences (ITP) West Pomeranian University of Technology (ZUT)	Informing – newsletter Informing – leaflet Exchange – bilateral conversation	
		Farmers	Farmers of the Gowienica river catchment	Exchange – multi-actor conversation	
		Farmer advisory and unions	West Pomeranian Farmer's Advisory Centre (ZODR)	Exchange – questionnaire/survey	
		Water producers and suppliers of drinking water	Szczecin Water Services West Pomeranian Water Services	Exchange – demonstration/field visit	
Mara	<ul style="list-style-type: none">• Most farmers are not aware that there are some problems related to bad agricultural practices. And if they acknowledge this, they still consider it as a small problem and certainly not their individual problem.	Regional/national government	Department of Environmental Protection, Szczecin City Hall Regional Water Management Authority, National State Water Farm Polish Waters (RWMA) Voivodship Inspectorate for Environmental Protection (VIEP) Regional Directorate for Environmental Protection (RDOŚ) West Pomeranian Board of Land Reclamation and Water Facilities in Szczecin (operated until 31.12.2017) Voivodship Fund for Environmental Protection and Water Management Agency for the Restructuring and Modernization of Agriculture (ARMA) Faculty of Infrastructure, Agriculture and Regional Development Westpomeranian Voivodeship Office	Exchange – interactive workshop	
		Local government	Warnice Borough Stargard Borough		
		Food processors and distributors	Polish Sugar Inc.		
		Inhabitants - consumers	Inhabitants		
		Action lab leader(s)	Universitatea Tehnica CLUJ-NAPOCA (UTC) Ecologic (civil society organisation)		Informing – newsletter Exchange – bilateral conversation
		Research	Universities Experts Students		Exchange – multi-actor conversation
		Farmers	Farmers of the Mara river catchment		Exchange – questionnaire/survey
		Farmer unions	Farmer association		Exchange – demonstration/field visit
		Regional/national government	EPA Maramures Directorate of Agriculture Maramures Water Directorate Maramures		Exchange – interactive workshop
		Local government	Ocna Sugatag Municipality County Council Maramures Budesti Commune		
		Industry - Tourism	Tour operators Ecotourism destination Ocna Sugatag Tourism Promotion Center		
		Inhabitants - consumers	Inhabitants of the villages		
			Children Priest		

Table 2 (continued)

Action Lab	Initial level of awareness	Actors involved	Strategies for engagement	
Lower Llobregat	<ul style="list-style-type: none"> Basically, all stakeholders, including farmers and citizens, are aware of the general bad quality of the water, but due to the complexity of the area it is difficult to know which activities are the most polluting. Farmers believe that agriculture is not the main source of pollution. On the contrary, agriculture in is perceived as beneficial to protect the area from further urban expansion. Farmers accept the use of treated wastewater for irrigation but demand improvement of its quality and control of specific parameters, as well as additional infrastructures to protect their crops from flooding or water shortages. 	<p>Action lab leader(s)</p> <p>Research</p> <p>Farmers</p> <p>Farmer advisory and unions</p> <p>Water producers and suppliers of drinking water</p> <p>Regional/national government</p> <p>Local government</p> <p>Food processors and distributors</p> <p>Inhabitants - consumers</p>	<p>IDAEA-CSIC (research organization, action lab leader)</p> <p>AB (local drinking water company)</p> <p>CUADLL (local water administration)</p> <p>CPABLL (local government)</p> <p>Agricultural Machinery Unity (UMA) of the Polytechnic University of Catalonia (UMA-UPC)</p> <p>Higher School of Agriculture of Barcelona attached to Polytechnic University of Catalonia (ESAB-UPC)</p> <p>University of Barcelona (UB)</p> <p>IRTA - research institute of the Government of Catalonia adscribed to the Department of Agriculture</p> <p>Illersap (analytical company)</p> <p>Students</p> <p>Famers of the Llobregat delta catchment</p> <p>Unió de Pagesos (major agriculture trade union)</p> <p>ADV Horta (farmers advisory)</p> <p>ADV Fruita (farmers advisory)</p> <p>ATLL</p> <p>Aigües d'El Prat</p> <p>FCC Aqualia SA</p> <p>Catalan Water Agency (ACA, basin water authority)</p> <p>Public Health Secretary (PHS) (Ministry of Health of Catalonia)</p> <p>Department of Agriculture, livestock, fisheries and food (Catalan government)</p> <p>AMB (Metropolitan area of Barcelona)</p> <p>Consortium of the Delta del Llobregat</p> <p>Municipalities Parc Agrari del Baix Llobregat: Palreja, Sant Vicenç dels Horts, Santa Coloma de Cervelló, Sant Boi de Llobregat, El Prat de Llobreta, Viladecans, Gavà, Castelldefels, El Papiol, Molins de Rei, Sant Feliu de Llobregat, Sant Joan Despí, Cornellà de Llobregat i l'Hospitalet de Llobregat.</p> <p>Mercabarna (wholesale market for the city of Barcelona)</p> <p>Inhabitants of the action lab area</p>	<p>Informing – newsletter</p> <p>Informing – project presentation and flyers</p> <p>Informing – press release</p> <p>Exchange – bilateral conversation</p> <p>Exchange – multi-actor conversation</p> <p>Exchange – questionnaire/survey</p> <p>Exchange – demonstration/field visit</p> <p>Exchange – interactive workshop</p> <p>Informing and exchange – conference</p>

door to a different approach in water and nutrient management. Another piece of legislation that can play a role in water management and agriculture is the Habitats Directive.

2.3.2. Methodology and policy evaluation framework

The policy analysis focuses on two fundamental questions:

1. What are the interactions between the various policies as well as the coherence, exchange of information and coordination at the implementation level?
2. How are the guidelines, requirements and rules in various policy instruments translated at farmer level in the Action Labs?

The choice of methodology was to structure the evaluation around the main stages of the policy cycle.

The policy cycle-based assessment has at the centre the policy instruments, hence facilitating the formulation of specific policy suggestions and recommendations (Fig. 2).

The evaluation of the water and agriculture policies coherence, coordination and interaction has included an extensive literature review on existing relevant reports and policy documents produced at EU level and/or commissioned by EU institutions.

To answer the first fundamental question the analysis has established a framework for all potential and possible interactions within the intervention logic for water and agriculture policies of the EU. The realities of implementation in the seven Action Labs areas were judged against this framework (see Section 3.1).

For the second fundamental question, the analysis has included a structured questionnaire collecting expert opinions from the Action Labs (see Section 3.2). The seven Action Labs (case studies) cover different climatic conditions, different types of farming systems, different

legal frameworks, larger and smaller water collection areas. Each Action Lab was chosen, based on the local specificities and pressures on water resources, to focus on nitrates and/or PPPs (Table 1). Hence, each Action Lab gave a different weight on what is considered relevant in the policy framework, based on the pollutant (s) of concern.

The Action Lab leaders were asked to evaluate the policy implementation realities in their study area using the following criteria:

- Effectiveness of the exchange of information and interaction;
- Coherence of the requirements, rules and guidelines (as perceived by the farmer);
- Relevance of the implementation mechanism in relation to the objectives; and,
- Added value of coordination and synergies between policy areas.

Due to non-availability of information or data on the efficiency and effectiveness of individual policy instruments in the Action Labs the assessment was based on expert opinions on the integration of water and agriculture policies using a structured set of 10 key questions (S1).

2.4. Identification of BMPs and MMs based on existing inventories

The first step in the analysis of the uptake of BMPs and MMs to prevent the pollution of drinking water sources from agriculture was to match the wealth of information from previous European projects that assess mitigation measures with the local knowledge of the farming systems and the focus issues in the seven Action Labs. The three projects consulted were TOPPS, MAGPIE and COMPASS:

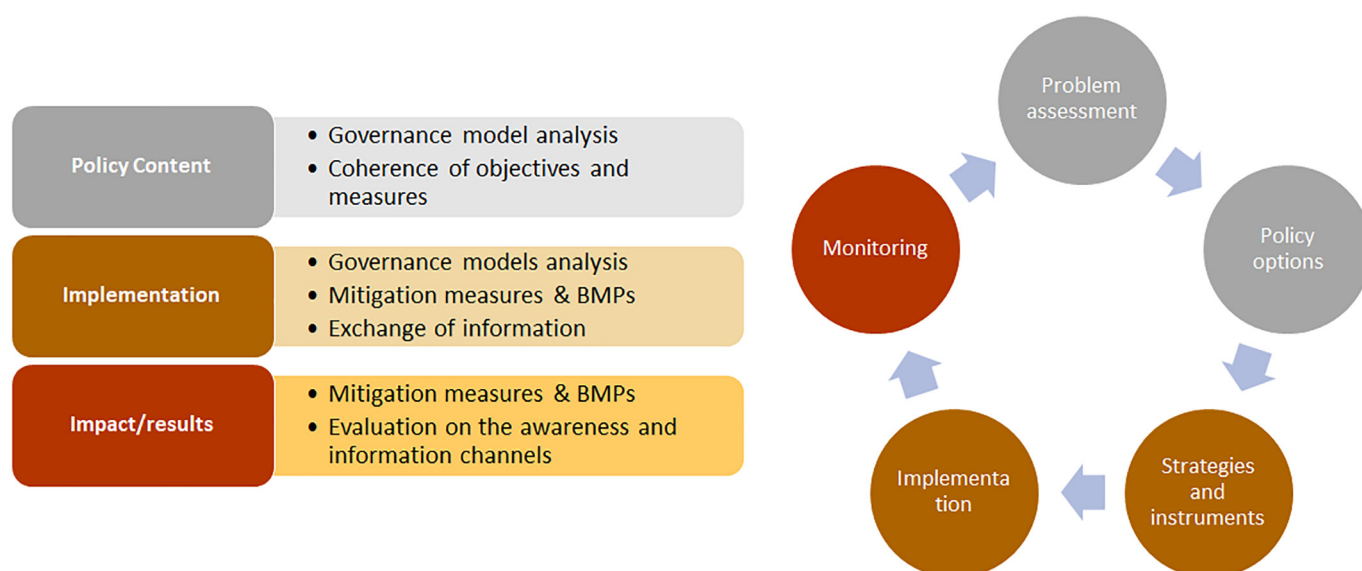


Fig. 2. Policy cycle-based analysis used by WaterProtect.

- TOPPS–Life project (<http://www.topps-life.org>) was designed as a multi stakeholder project to reduce losses of Plant Protection Products (PPP) to water. The project was funded by the EU through the Life program and the ECPA (European Crop Protection Association). The project started in November 2005 and ended in October 2008 and the TOPPS extension program supported by ECPA is still running. In various TOPPS projects a broad range of information, training materials and BMP recommendations to reduce PPP losses to water has been developed (point sources, spray drift and runoff). Key perspectives are the correct behaviour of operators, improved equipment and infrastructure.
- MAGPIE (<https://www.setac.org/magpie>) is a comprehensive overview of the state of pesticide risk reduction and pesticide risk mitigation in cultivated landscapes. The project gathers results of numerous detailed discussions that took place over two workshops and 3 years of intensive work and data analysis by 95 experts and regulators from 24 European countries with a common objective: “translating science into applicable solutions to farmers for a safer use of pesticides for the environment”.
- Baltic COMPASS project (Comprehensive Policy Actions and Investments in Sustainable Solutions in Agriculture in the Baltic Sea Region, <https://balticcompass.org/>) was funded by EU through the Baltic Sea Region (BSR) Programme 2007–2013 and involved 22 partners from 9 countries in the Baltic Sea Region: Belarus, Denmark, Estonia, Finland, Latvia, Lithuania, Germany, Poland and Sweden. The project aimed at strengthening cooperation between agriculture and environment sectors to answer to the need for a transnational approach to reduce eutrophication of the Baltic Sea.

The BMPs selected were chosen on the basis of protecting drinking water sources from nitrates and/or Plant Protection Products. While some technical measures provide solutions for a wide range of pollution problems, such as grass buffer zones or constructed wetlands, others are more problem specific, such as phytase supplementation or drift reducing nozzles. Non-technical measures focus on changes in behaviour rather than the use of technology or techniques, such as only spraying when weather and field conditions allow safe PPPs use. Other BMPs require new or improved technologies or infrastructure, such as the management of polluted water derived from cleaning of sprayers. Many of these measures are well known across Europe but are not all fully implemented. In addition, these measures may simply not be appropriate for a given farming system, due to the physical characteristics of the area and/or the prevailing socio-economics of the farming sector in an Action Lab. Therefore, the Action Lab leaders did a first assessment of the relevance of selected BMPs in the Action Labs, including a discussion with stakeholders in the field (farmers, farm advisors, government and non-government officials). This resulted in an extension of the basket of BMP measures from 56 to 77 (S2). These are grouped into seven categories of BMPs (Table 3) reflecting the pollutant focus – nitrates and/or PPPs and whether the measures are related to soil management, farm operations, or animal husbandry.

One category of measures focuses on practices in animal husbandry and manure management (*N1Manure*) and contains farm practices such as e.g. reducing the dietary nitrogen and phosphorus intake or adopting phase feeding of livestock. Also, in this category are management practices on the field such as incorporating manure immediately after application on cultivated land. Another category of BMPs & MMs focusing on

Table 3
Overview of BMP and MM categories for pollutant control.

Type of pollutant	Category of BMP and MMs	Number	Action Lab survey
Nitrates & PPPs	Soil management & Plant production – runoff mitigation (N&PPP) ^a	16	ES, IT, RO, DK, IE, PO, BE
Nitrates	Animal production & Manure management (N1Manure)	16	ES, RO, DK, IE, PO
	Soil management & Plant production (N2Soil)	10	ES, RO, DK, IE, PO
PPPs	Soil management & Plant production – PPP runoff mitigation (PPP1Soil) ^a	3	IT
	PPP point source prevention (PPP2Point)	15	ES, IT, IE, PO, BE
	PPP spray drift mitigation (PPP3Drift)	12	ES, IT, IE, PO, BE
	General precautionary measures (PPP4General)	5	ES, IE, PO, BE

^a PPP1Soil is focused on PPPs and N&PPP is focused on both N & PPPs.

nitrate is related to soil management plant production practices (N2Soil). Included here are e.g. making a nutrient balance on farm and/or field level, using treated urea or liming. A specific subgroup of soil management practices is related to mitigating runoff and is equally relevant for nitrates and PPPs (N&PPP). This category contains runoff control measures such as grass buffer zones, crop rotation to preserve organic matter or establishing retention structures. A small category of measures is related to control of diffuse losses specifically for PPPs (PPP1Soil): permanent grassing in the interrow and weeding the row, considering alternative systems for pest control. For PPPs, three more categories are delineated focusing on point source prevention (PPP2Point, e.g. use a safe filling and cleaning place for the spraying equipment), on spray drift mitigation (PPP3Drift, e.g. use drift reducing nozzles) and general precautionary measures (PPP4General, e.g. ensure adequate training for sprayer operator).

2.5. Questionnaire survey to assess the uptake of BMPs and MMs in Action Labs

In each of the Action Labs a questionnaire was developed to take to the farmers. The objective of the survey was to gather information regarding the uptake of BMPs and MMs within the Action Labs (Table 4), and to assess the willingness of farmers to implement additional, innovative measures, depending on costs and benefits. Each Action Lab selected a number of BMPs and MMs from the basket of measures based on the relevance for the area (targeted type of pollutant, well established and novel approaches, critical pollutant routes in the area). This resulted in 7 different questionnaires that started from the same objective but contained different lists of BMPs and MMs.

The coverage of the survey in the different Action Labs varies but is considered good: for Bollaertbeek the 49 farmers represent 44% of the farmland and 30% of all farmers, with a relatively higher proportion (56%) of farmers that spray themselves compared to farmers using a contract sprayer. In Wexford, 44% of the farmers responded to the survey. In Val Tidone the survey was conducted in two stages with 175 farmers (38%) taking part in the general survey including BMPs on point pollution (4 BMPs) and 50 farmers (11%) in the second survey including BMPs on diffuse pollution (14 BMPs). In Gowienica 60% of the farmers took part in the survey covering 93% of the farmland. In Mara River 29% of the farmers responded representing 6.2% of the catchment. In Lower Llobregat River the survey was taken by 24 farmers that are members of a Plant Protection Association (receiving training and advice) and by 5 farmers that are not. Non-professional farmers could not be reached but the overall response rate was 12%. In Vester Hjerker 7 out of 8 farmers in the capture area were reached (representing 90% of farmland in the capture area) and some additional farmers in the supply zone.

The majority of the Action Labs also included obligatory BMPs and MMs in the questionnaire (between 10% of the list in Gowienica up to 56% in Lower Llobregat) while two Action Labs only focused on the uptake of voluntary measures (Val Tidone, Vester Hjerker) (Table 4). Obligatory BMPs and MMs are either mandatory by national law (evaluated in each Action Lab separately) or, in the case of Bollaertbeek, mandatory for certification to be allowed to sell the crop (vegetables) on the

market. Voluntary measures are not mandatory by law and can in some cases be eligible for funding from Rural Development funds (e.g. as erosion-control or biodiversity promoting measures).

2.6. Follow up surveys to identify the barriers to the uptake of BMPs and MMs in Action Labs

Follow up work was carried out after the questionnaire surveys, in line with the multi-actor engagement techniques (described in Section 2.2), with the specific objective to establish the barriers to the uptake of BMPs and MMs, so as to understand what motivates farmers to adopt voluntary measures and what holds them back. An iterative process was adopted by the Action Lab leaders (Table 1) from which a check list of possible barriers was established – this was used as a template to interview the farmers again to understand the underlying barriers that influence decision making. The checklist of barriers was further organised into the following categories: organisational, legislative, sociological, political and technical. The basket of collaborative tools and results were further used to reflect on how the policy instruments could be better used to improve awareness, collaboration and in some cases the uptake of BMPs and MMs in the Action Labs in the future.

3. Results

3.1. Possible interactions within the intervention logic for water and agriculture policies

The intervention logic describes the way various elements of a policy aim at influencing the target groups towards achieving common objectives. The EU policies are developed in an intervention logic that seeks to combine various policy instruments and secure synergies to achieve a multiplier effect on the ground. However, the reality is much more complex in the Action Labs where various specific conditions, administrative organisation or local culture and ways of working, can facilitate or hinder such policy interactions. This enabled us to develop an evaluation framework that maps out the potential interactions that exist between policy implementation instruments (Fig. 3), leading to an assessment of what the intensity and effectiveness of policies are in each Action Lab.

3.2. Integration of the water and agriculture policies in the Action Labs

EU Directives are completed by local state legislation, whereas European Legislation constitutes the basic pillar of legislation in Member States pertaining to e.g. protection of groundwater, buffer zones around water bodies, and management of water, it is transposed and implemented by local structures. For instance, the River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs) required by the WFD, are developed and managed by the water authorities and are obviously specific for each basin.

High amounts of data regarding water quality are currently routinely collected and in the last decades by various institutional actors regarding microbiology and physical-chemical and quality-related parameters. However, there are current gaps in data sharing: although legislated parameters are shared among different institutions, the inclusion of research project results in a common database and open access of not regulated parameters is still not implemented. Research data are only available through scientific publications or project reports.

The general assessment is that the Rural Development Plans do make use of the information collected in the implementation of the water related policy instruments. In general, this is done at a higher integration level and contextualising the information into the specific objectives of rural development.

The type of data used is not homogenous in the EU, some countries make use of general statistical data, some explore the monitoring data

Table 4

Overview of the number of farms, number of BMPs & MMs in the survey, and number of BMPs & MMs that are obligatory for each Action Lab.

Action Lab	# Farms	# BMPs & MMs surveyed	# obligatory
Lower Llobregat	29	33	19
Val Tidone	175	18	0
Mara River	40	18	7
Vester Hjerker	10	11	0
Wexford	35	32	6
Gowienica	72	29	3
Bollaertbeek	49	30	8

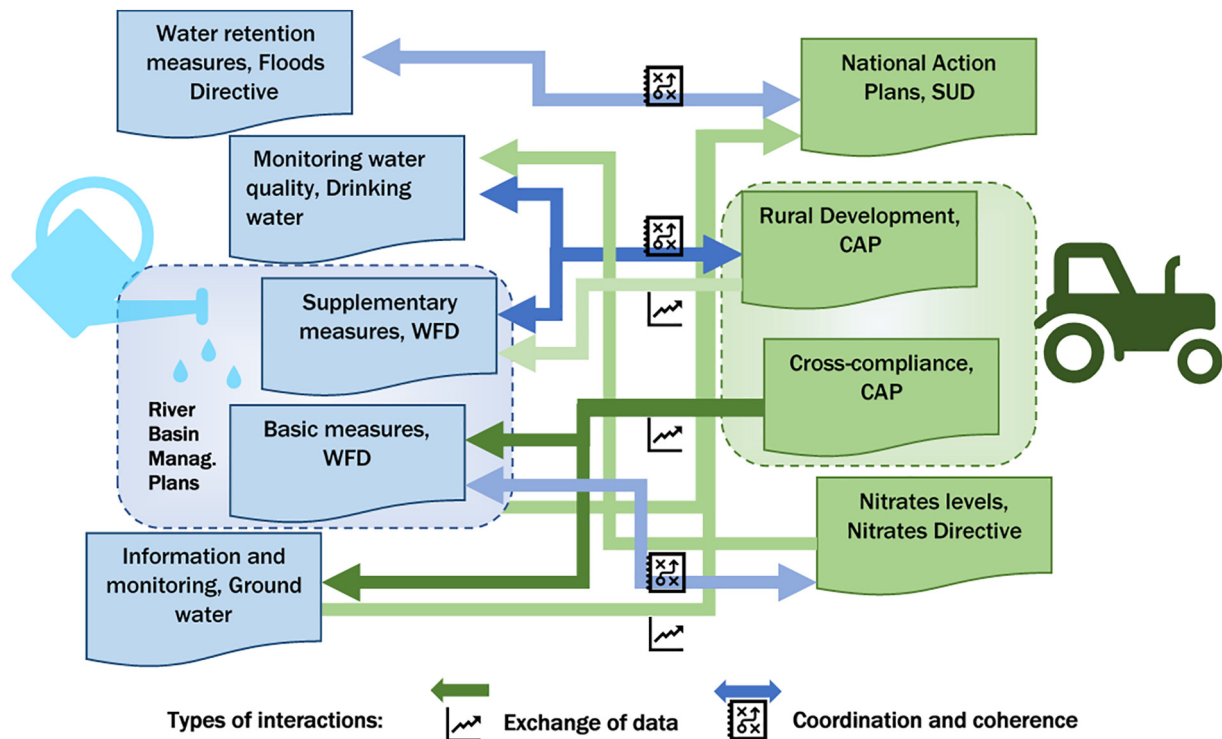


Fig. 3. Evaluation Framework: opportunities for interactions and exchange of information between various EU water and agriculture related policy instruments.

in detail while others integrate such data with specific assessments and evaluations done by recognized national or local organisations.

When it comes to evaluating the coherence between Rural Development and RBMPs, again, the level of integration varies between countries. However, in general, the two programming instruments seem to be generally correlated.

National action plans adopted, as required by the Sustainable Use of Pesticides Directive 2009/128/EC (European Parliament and Council, 2009), include quantitative objectives, targets, measurements and timetables to reduce the risks and impacts of pesticide use. Water resources and recommendations are made for taking appropriate risk mitigation measures on the territory to avoid pesticides contamination of water resources.

Farmers receive information on the standards to be followed through many channels, mainly from the farmer associations and farmer advisory centres. They issue guidelines and management practices to make requirements clear and feasible in practice, which is not always possible since the legislation is not always coherent in definitions and concepts.

Through the expert analysis we can conclude that there is a certain level of complexity for the implementation of the EU legislation at national level, which is often influenced by the political context, administrative or organisational specificities, history or culture of participatory policy making and public consultation.

Provisions and national level requirements on water protection are considered to be generally coherent and no contradictions between objectives or measures for their implementation were identified by experts. However, the complexity of the implementation arrangements translates into a difficult communication on the objectives and the related means or measures in place for their achievement.

3.3. The uptake of voluntary BMPs and MMs in Action Labs

The number of voluntary measures per Action Lab addressed in the questionnaire survey ranges from 11 (Mara and Vester Hjerik) to 26 measures (Gowienica and Wexford). The percentage uptake by farmers

of one quarter of the measures per Action Lab ranges from 22% (Vester Hjerik) to 88% (Gowienica). This means that in Vester Hjerik 3 out of the 11 voluntary measures were implemented by 2 out of 10 farmers, whereas in Gowienica 6 out of 26 voluntary measures were implemented by 63 out of 72 farmers. Information about the potential uptake of voluntary measures in the Action Lab ranges from 13% of farmers in Gowienica to 90% of farmers in Mara adopting 10% additional selected measures. This clearly indicates that the potential uptake of voluntary measures has to be assessed in the context of the different Action Labs (Fig. 4).

In each of the Action Labs there is a mix in the number of voluntary measures, of measures that are well-established, and measures that are not implemented at all. There is a large variation as to what is used within countries. Often reduction of water pollution can be achieved by changes in the behaviour of operators, which can usually be applied cheaply. Other BMPs require new or improved technologies or infrastructure, which is more expensive. Many of these measures are well known in EU countries but were not fully implemented.

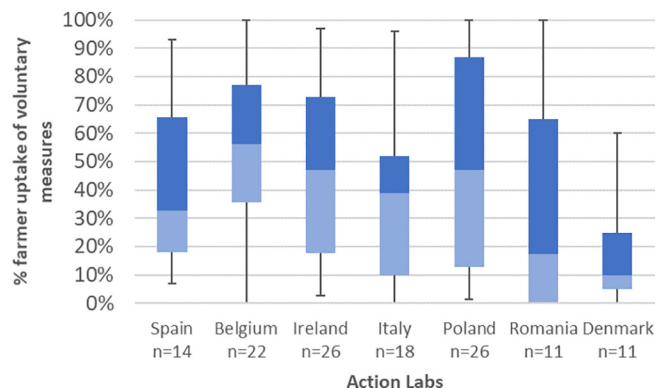


Fig. 4. Uptake of voluntary measures by farmers in each Action Lab (light shading 25% percentile to median, dark shading median to 75% percentile).

BMPs which are currently implemented and those that were deemed to be implementable mostly are small and simple measures that do not require big investments or big adaptations in the farming system and/or offer clear benefits to farmers; examples of these are keeping soil cover in autumn and winter (high uptake in Wexford, Bollaertbeek, Gowienica and Mara River) or not spraying non-target areas (high uptake in Val Tidone, Gowienica, Wexford (mandatory) and Bollaertbeek). Increase in productivity is a strong incentive for farmers to implement BMPs (e.g. crop rotation to preserve soil organic matter) while environmental aspects such as need for minimization of the risk of drift of PPPs or nutrient losses to the environment are poorly recognized by farmers in some cases, depending on the awareness of the water quality issues.

Knowledge on and perception of effectiveness and usefulness of different BMPs varies between countries. For example, results of the survey in Wexford suggest poor performance of constructed wetlands and therefore low potential for implementation of this measure. In contrast to that, in Vester Hjerik landscape level BMPs such as constructed wetlands, set aside and afforestation seem to have a relatively high potential. Larger and more expensive measures are more difficult to implement; nonetheless measures perceived as being immediately beneficial for farmers (i.e. giving long term financial benefits) have relatively high potential for implementation. For example, the use of GPS technology in farming shows high potential for implementation in Wexford, Gowienica and Vester Hjerik.

Other measures recognized as effective but not giving direct benefits to farmers, e.g. anti-hail nets are not considered interesting or applicable, mainly due to the excessive costs. For these measures, financial incentives would be necessary to increase their implementation. Implementation of measures that require land area, such as for example vegetated buffer strips at the edge of a field or within a field, are not welcomed by farmers due to loss of land for agricultural production. However, farmers in Gowienica indicated that they would be in favor of them if given land tax exemptions for these areas and/or state/commune support in preventing weed infestations.

In some cases (Vester Hjerik, Bollaertbeek, Gowienica) there is a positive approach to collaborative solutions, where more farmers and stakeholders are involved. For example, farmers indicated they would

welcome a solution where a common, public cleaning place for cleaning sprayers was provided. Organising these solutions needs facilitation of dedicated institutions and/or a leader with good communication skills, as making a consensus among farmers themselves to work together has also been identified as a potential barrier. Some cases (Val Tidone, Bollaertbeek) highlighted that farmers showed to be open for cooperation and expressed their interest in obtaining more information about specific BMPs or how to mitigate defined problems. In another Action Lab (Gowienica) farmers admitted to participating in many trainings related to BMPs, however these were “too theoretical” and hence were not effective since they did not sufficiently contribute to understanding the problem.

3.4. Barriers to the uptake of BMPs in Action Labs

The follow up survey after the formal questionnaire to determine the rate of uptake of and potential interest in voluntary BMPs and MMs revealed that there are a wide range of barriers that can be categorised under: organisational, legislative, sociological, political and technical (Table 5), which are fully described in S3 based on accompanying field notes.

The barriers that occur in three or more of the Action Labs provide guidance in terms of commonality and provide policy makers the required focus on the issues that are troubling farmers. The barrier that was most commonly pointed out (by 6 out of 7 participating Action Labs) was too complex organisational set up of institutions responsible for implementation and execution of water management policies. This was highlighted by Poland, Italy, Spain, Romania, Ireland and Belgium. The general conclusion is that there are too many institutions involved in water management at national and regional/local levels, which causes roles and responsibilities to be unclear and sometimes overlapping. Many countries noted a definite dispersion of competences and a large variability in the stakeholders' perception of the water governance structure and the stakeholders' roles. This confuses farmers and discourages them to contact specific authorities and inhibits uptake of measures.

Little cooperation between stakeholders at local level was pointed out by 5 of out 7 action labs (Poland, Italy, Spain, Belgium and Romania) as another important factor hindering the effectiveness of measures. By lack of

Table 5
Key barriers that prevent the uptake of BMPs in the seven Action Labs.

Barriers	No. of occurrences	Action Labs (countries)	Type	scale
Too complex organisational set up of institutions responsible for implementation and execution of water management policies	6	BE, IE, RO, ES, IT, PO	Organisational	National/local
Little cooperation between stakeholders and lack of communication and exchange of information	5	PL, IT, ES, RO, BE	Organisational	Local
Regulations from different policy areas, such as groundwater, surface water, drinking water, agriculture and nature conservation are poorly coordinated	4	PL, IT, BE, DK	Legislative	National
Low awareness of farmers regarding impacts they may cause on the environment	4	PL, IT, RO, BE	Sociological	Local
Inefficient control mechanisms (lack of actions towards non-compliance)	3	PL, RO, BE	Legislative	National
Standards and recommendations from applicable law and action programs are not fully adapted to the occurring climate changes	3	PL, ES, IE	Legislative	National
Systems of support incentives for BMPs are too little	3	PL, RO, BE	Legislative	National
Too little financial support for implementation of more advanced measures that are expensive	3	IT, ES, IE	Legislative	National
Too much bureaucracy	3	PL, IT, BE	Legislative	National
Lack of knowledge transfer from science to policy	3	PL, ES, BE	organisational	National/local
Lack of long-term vision for environmental protection	3	PL, ES, BE	Political	National
Time is needed for stakeholders to adapt to changes	3	IT, ES, IE	Sociological	National
Lack of interest in participation in the process of law creation	3	PL, ES, RO	Sociological	National/local
Multiplicity of regulations, which are often unclear	2	IT, ES	Legislative	National
Regulations are not adequate for the scale of the problem	2	IT, DK	Legislative	National/local
Very centralized authorities impacting on the access to information, data and cooperation	2	PL, RO	Organisational	National
Underfunding of institutions from the water management, environmental protection sector, and agriculture departments makes the implementation of necessary improvements difficult	2	PL, ES	Political	Local
Small impact of consumers on agricultural production	2	PL, ES	Sociological	Local
Inadequate data to establishment link between agricultural activities and quality of water	2	IE, DK	Technical	Local
High costs of monitoring	2	ES, IE	Technical	Local
Tools used for planning are based on models that allow for no or very little differentiation of the area	2	ES, IE	Technical	Local

cooperation it is understood that there is not only little integrated effort in defining and implementing measures (which relates to point 2), but also a lack of communication and exchange of information. This further implies that the voices of some stakeholders are not heard by others and that actions taken by the government officials favor specific groups of stakeholders. This was highlighted by farmers during multiple workshop meetings in Poland, Belgium, Italy, Romania and Spain.

Regulations from different policy areas, such as groundwater, surface water, drinking water, agriculture and nature conservation are poorly coordinated. This was indicated by 4 Action Labs: Poland, Italy, Belgium and Denmark. Regulations developed by different governmental departments are only focused on their own interests. This creates situations where finding practical solutions at a local level is very difficult, as requirements of one regulation often contradict requirements of the other. On the other hand, the implementation of one measure can often fulfill requirements of more than one regulation and this could significantly boost their effectiveness, reduce costs and allow for more measures to be introduced. This requires good coordination and an integrated water management at local levels.

In addition, low awareness of farmers regarding impacts they may cause on the environment has also been identified as an important barrier, noted by 4 out of 7 action labs (Poland, Italy, Romania, Belgium). The field assessments revealed that farmers in general still have a problem with linking how their everyday activities may affect the environment. It has been noted that the economic sustainability of the activity prevails over environmental sustainability. The family economy and personal goals influence the transition to sustainable agriculture. Nonetheless, this links closely to the problem of little transparency of environmental monitoring programmes which do not inform farmers about their findings. Farmers are not aware about water quality results from national/regional water monitoring campaigns in their areas and as such are not aware of impacts they make.

Another common barrier highlighted by 3 out of 7 action labs (Poland, Italy and Belgium) was the multiplicity of regulations, which often are unclear. Farmers need to be aware of multiple regulations regarding nitrates, ammonia, PPP, erosion control, etc. some of which are very long and complex. This causes regulations to be difficult to apply and to control in practice not only by farmers, but also by civil servants.

Three out of seven action labs (Poland, Romania and Belgium) indicated inefficient control mechanisms to be factors inhibiting implementation of measures. There are two aspects in here to be considered. First of all, lack of actions taken towards those that do not fulfill legal requirements makes farmers to feel above the law and do not motivate them to take actions. Another aspect that has been highlighted by farmers themselves is that the lack of control and actions towards those who break the law discourages farmers that take actions and do things according to legal protocols. An additional problem highlighted by farmers in Poland is that the level of environmental fines is too low for large scale farmers to respect. Farmers often admitted themselves that breaking laws and paying fines was more worthwhile to their business than taking up mitigation measures required by law.

Farmers in Poland, Spain and Belgium pointed out that the lack of long-term vision for environmental protection with respect to water and agriculture is an important problem. This relates to frequent changes in regulations and lack of continuity in approaches taken. The environment needs time to respond to changes that have been introduced. Belgium highlighted that regulations change too often and become stricter and stricter every few years. Farmers, who already implement measures and try to do their best are often 'penalised' when stricter rules are imposed. As a result, farmers lose their faith in legislations; they become suspicious and refuse to implement measures on a voluntary basis. In the Water Protect workshops, farmers asked for a clear and long-term vision from the government. The typical 4-years duration of governments does not allow to advance in questions that require more time for its implementation.

In Italy, Spain and Ireland farmers noted that time is needed for stakeholders to adapt to changes. This regards not only logistical issues such as time needed for utilization of older products that have been made prohibited but may still be stored by farmers, but also mental ability of people to adapt to changes such as the implementation of new measures.

In Poland, Spain and Ireland farmers think that standards and recommendations from applicable law and action programs are not fully adapted to climate changes (e.g. mild winters and earlier start of the growing season, and periods of allowed fertilization).

Farmers in Poland, Romania and Belgium advocated that systems of support incentives for best practices in relation to water management as well as for agro-ecological approaches are too little. In Poland, there are premises that cultivation on a particular land is more beneficial than applying new voluntary BMPs and receiving subsidies for that action. This is especially visible in areas with rich soils that can be cultivated intensively with profitable results. As a result, little interest is given for new more environmentally friendly initiatives on a voluntary basis.

In Italy, Spain and Ireland farmers highlighted that there is too little financial support for implementation of more advanced measures that are expensive. These measures can be attractive to implement but their cost and complexity can hinder straightforward implementation.

Too much bureaucracy is a common complaint expressed by the farmers. Filling of paperwork required from farmers causes additional costs and confusion (Poland, Italy and Spain).

Three countries, namely, Italy, Poland and Ireland noted the lack of knowledge transfer from science to policy. Policy and science are not commonly integrated causing knowledge gaps where decisions are made. Important research findings are not efficiently disseminated to the right stakeholders or are not acknowledged enough in order to support decisions on the right measure, in the right places and at the right time. For example, the Action Lab studied in Poland has a very long-lasting history of research, yet their findings have not led to changes in local policies and regulations.

Lack of interest in participation in the process of law creation. Polish, Spanish and Romanian partners informed that consultation (in general, and specifically with respect to water management) is still a process that needs to be learnt and few people are interested to participate in the consultation, mainly specialized NGO's or directly interested stakeholders. Farmers have little confidence that their opinions will be incorporated, so they have little motivation to participate.

4. Discussion

As a team we set out a methodology of multi-actor engagement that started at the same point but needed to be adapted to the local context, meaning that the execution of the approach was different. The strength of this method meant that the individual teams in the Action Labs could ensure that farmers and other actors were properly engaged in a meaningful and relevant way, with a consistent policy and field assessment framework. The weakness was that standard statistical comparisons concerning the uptake of BMPs and MMs to protect drinking water sources from nitrates and PPPs cannot be inferred. We therefore discuss our results in a qualitative manner to guide our recommendations and conclusions. We look to match the level of awareness that farmers expressed about water quality issues at the start of the process (Table 2) to the uptake rates of BMPs and MMs observed at the Action Lab level (Fig. 4). This is further discussed in light of the barriers to taking up measures identified during the follow-up surveys (Table 5), accounting at the same time for the policy evaluation framework that identifies potential interactions between policy instruments (Fig. 3).

4.1. Action Labs that focussed mainly on PPPs (Bollaertbeek – Belgium, Val Tidone – Italy, Wexford – Ireland, and Lower Llobregat – Spain)

At Bollaertbeek (Belgium) there was a mixed level of awareness about the potential impact of spraying PPPs – with contract sprayers

being in general more aware than farmers. In Wexford (Ireland) on the other hand there was in general a good awareness that the PPP MCPA (a 2-methyl-4-chlorophenoxyacetic acid - a herbicide) is a potential problem for drinking water supplies further down the catchment, although there was inadequate knowledge about the pollutant transfer pathways. At the Lower Llobregat (Spain) basically all stakeholders, including farmers and citizens, were aware of the general bad quality of the water, but due to the complexity of the area it is difficult to know which activities are the most polluting. On the whole farmers believe that agriculture is not the main source of pollution. In Val Tidone (Italy) there was also very little awareness from the farmers that PPPs might have a deleterious effect on the local groundwater. Participatory monitoring in all Action Labs was therefore essential to show farmers and other stakeholders that pollution from agriculture was indeed an issue. In terms of the rate of uptake of voluntary measures to reduce the impact of PPPs one quarter of the 22 voluntary measures were already being implemented by 78% of the farmers surveyed in Bollaertbeek with 34% of the farmers are considering additional selected measures in the future. This was very similar to the situation in Wexford where a quarter of the 26 voluntary measures were already being implemented by 73% of the farmers surveyed, with 26% of the surveyed farmers considering to implement additional selected measures in the future as well. This rate is slightly lower at the Lower Llobregat Action Lab where a quarter of the 14 voluntary measures were already being implemented by 66% of the farmers surveyed but up to 63% of the surveyed farmers considering implementing additional selected measures. Even though the general level awareness of water quality issues in Val Tidone was low already 52% of the farmers were implementing a quarter of the voluntary measures, although 25% of the surveyed farmers considering implementing additional selected measures in the future. In addition to low awareness the other typical barriers to the uptake of BMPs and MMs in all Action Labs were complaints about the complexity of the legislation and follow-up, including the inherent bureaucracy involved. In addition, farmers in Bollaertbeek also found that some of the mitigation measures, such as buffer zones, were technically confusing and difficult to implement, whereas on the other hand they are looking for measures that could reduce spray drift better. It was felt that there were also not enough control mechanisms to deal with non-compliant farmers, which was a complaint. In addition, farmers in these Action Labs indicated that there was insufficient financial support now to encourage them to step into the voluntary measures requiring major investments. The farmers in Val Tidone also found that some of the measures being promoted were not even suitable for their particular landscape and setting.

4.2. Action Labs that focussed mainly on nitrates (Gowienica - Poland, Mara - Romania and Vester Hjerik - Denmark)

At Gowienica (Poland), even though the environmental agency has been operating a nitrate vulnerable zone for more than 12 years, the farmers in the area had very little awareness that nitrates are polluting the surface and ground waters. In Mara (Romania) this lack of awareness was also apparent. In Vester Hjerik (Denmark) the assumption from the farmers was that if there was a problem in the drinking water supply this would be dealt with by the local water utility company. In terms of the percentage of farmers taking up voluntary measures, a quarter of the 26 voluntary measures were already being implemented by 88% of the farmers surveyed in Gowienica with 13% of the surveyed farmers considering implementing additional selected measures. This contrasts greatly with Vester Hjerik where only 24% of farmers were taking up one quarters of the 11 voluntary measures with 30% of the surveyed farmers considering implementing additional selected measures. Meanwhile in Mara one quarter of the 11 voluntary measures were already being implemented by 64% of the farmers surveyed, but almost 90% of the farmers were considering implementing additional selected measures in the future. In addition to low awareness

the other typical barriers to the uptake of BMPs and MMs in all Action Labs were the complex and poorly coordinated legislation and actions from the different government agencies, the lack of specialized personnel to provide professional guidance on measures, and the perception that there were insufficient control mechanisms for compliance. In Gowienica and Mara - formerly eastern bloc countries - the farmers found the approach of authorities too centralized with a lack of information. In Vester Hjerik the hydrogeology is very complicated so that it was questionable whether there is a direct link between surface measures carried out by farmers and the impact on groundwater water quality.

4.3. All Action Labs

In terms of using the policy evaluation framework that identifies interactions between policy instruments it is clear that policy instruments have to begin to address the organisational, legislative, sociological and technical barriers to the uptake of BMPs and MMs. At the farmer level the most important barrier after low awareness is that the process for them to take up BMPs and MMs is too complex and uncoordinated. This calls for legislation and regulations from both the ministries (or departments) of agriculture and environment to be simplified and integrated. Clear and unambiguous messages on production standards and requirements is needed. The measures should also be selected in an open and constructive dialogue, which take into account aspirations but also limitations and difficulties of the different actors. Furthermore, the measures should be feasible in practice and if the measure involves extra costs without any return on investment for the farmer, it is clear that improved financial incentives need to be provided. With limited public finances it is therefore necessary that cooperation and synergies between the various institutional actors funding measures to be improved.

While the purpose and technical aspects are usually quite clear and straight forward, the desired transition towards a 'new normal', including standardization and education of Best Management Practices is almost never completed towards satisfying and long-lasting levels. Matters of organisational, financial or cultural origins, which are inevitable occurrences of life seem to keep us away from what is sensible to do. The long value chains that we have built for our food production dilute both the impact and responsibility which the involved people experience.

There is however, a huge common success factor: bottom up societal support. This creates peer pressure to continue performing, when times are getting tough. Sometimes, extreme events like water quality issues, drought, heavy rain, Covid-19, trigger the justification of rapid implementation of BMPs, and addressing the barriers for uptake is an important outcome of WaterProtect. This can go very fast, whereas the usual uptake is often a long and difficult process. A conclusion is that the building of societal acceptance, the communication of issues and solutions before the start, are the crucial success factors for a multi-actor, participatory approach to improve farm management practices and protect our drinking water sources.

5. Conclusions

The EU policy architecture that governs the water and agriculture areas is complex, partially due to the historical evolution of the two EU policy areas, but also partially due to the complexity of the challenges these need to address. Coherence of water and agriculture policies at EU level is recognized as an area where improvement is needed. Several actions have been taken at political and technical level, but there are also further opportunities for improvement. We have first taken the step to assess the situation by embarking on a multi-actor engagement strategy in the seven Action Labs. From this assessment we can conclude that the general awareness of farmers about the potential pollution problems caused to drinking water sources by the applications of nitrates and PPPs is low. Despite this low awareness

between 24% to 88% of the surveyed farmers per Action Lab were already voluntarily adopting one quarter of the selected BMPs and MMs. Information about the potential uptake of voluntary measures in the Action Lab ranges from 13% to 90% of the farmers being willing to adopt additional selected measures. The follow up surveys provided us a better understanding of what is preventing farmers from taking the step to incorporate voluntary BMPs and MMs in their farm management. Therefore, we can conclude that the next steps are to address the complexity of the process (administrative and technical), the lack of coordination between the different institutional bodies promoting measures, and the financial incentives needed to invest and operate these often-costly measures will increase the likelihood of more farmers taking up BMPs and MMs.

With these points in mind and using the analysis on the coherence of water and agricultural policies and cross-referencing those with the implementation realities, we can make the following policy recommendations:

1. The EU should exploit the cycles of policy revisions to better integrate objectives and create mechanisms and structures of coordination.
2. The strategic planning foreseen in the new implementation arrangements of the CAP after 2021 needs to be fully exploited to ensure coherence of objectives for water management and agriculture at national level, given that the new policy implementation arrangements give more flexibility to EU Member States in deciding agricultural policy priorities, and to allocate much needed resources for farmers to make a positive contribution to sustainable water management.
3. Member States should strive to streamline the implementation structures and procedures based on sound governance concepts that ensure the involvement of all concerned stakeholders in sustainable management of water resources & agriculture.
4. Future policy implementation approaches should state the need for further exchange of information and data between the various programmatic and enforcement instruments and structures. Results of controls over agricultural activities will have to influence priorities in water management and, equally, information on water quality and quantity issues, should be better transferred to the farmers.
5. Promoting multi-actor, participatory water governance models are recommended due to their capacity to: easily transfer information on the water management challenges, collaborative development of solutions, capacity to address local specificities and limitations and can create synergies with other action areas.
6. Proactive provision of information on the challenges in water quality and their potential cause are essential to ensure awareness at farm level and understanding of the positive contribution farmers can make. Currently, information is often unclear, scattered or not easily accessible. In many cases farmers rely on informal channels (farmer associations, media, extension consultants, etc) to obtain such information.
7. The positive contribution to sustainable water management of agriculture, including through implementing BMPs and MMs should be evaluated, recognized and communicated. A set of indicators that highlight the contribution agriculture has into water management (able to capture positive and/or negative trends) will help with farmers' involvement of and will stimulate ownership of the process.
8. Perception on costs vs. benefits of implementation of various BMPs or MMs have an important impact on the willingness of farmers to implement them. Hence, direct information, know-how and as well as support for actual investments needed for implementation of will play a key role in the future uptake of such measures by farmers.

Finally, on the basis of the approach to improve awareness, collaboration and in some cases the uptake of BMPs and MMs in the Action Labs the crucial success factors to achieve this are to build social acceptance among all actors and to communicate the issues and potential solutions right from the start.

CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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